

Report for 2004KY44B: Assessing groundwater age, regional flowpaths, and hydrochemical evolution of the Knox Group Aquifer in the Bluegrass Region of Kentucky

There are no reported publications resulting from this project.

Report Follows

Problem and Research Objectives

The Cambro-Ordovician Knox Group dolomites of Kentucky are host to a regionally extensive aquifer system that could potentially play an important role in future water resource developments in the region. Preliminary water quality assessments, based largely on total dissolved solids concentrations from wells drilled into the Knox Group, identify large portions of the aquifer as being saline. However, a freshwater portion of the aquifer in the central Bluegrass Region is potentially useful for rural and suburban supplies. The study expands on previous work in order to 1) define the age of Knox Group ground waters along locally-inferred flowpaths, 2) identify regional flowpaths, including important recharge-discharge zones, and 3) characterize the evolution of ground water within the Knox Group. The research relies largely upon isotopic tracers to uncover differences in ground water characteristics that can be used to infer ground water age and the processes that alter water chemistry. A clearer understanding of flow regime and rates of ground water movement within the Knox Group aquifer will yield a more effective strategy for exploitation of water resources within the Bluegrass Region.

Ground water recharge into, transport within, and discharge out of the Knox Group aquifer is complex due to regional (Cincinnati Arch) and localized (fault zone, jointing) structural controls and because of the high salinity of formation waters (brines). The study seeks to provide a stronger temporal and spatial context by which to view ground water transport through a regionally-extensive deep aquifer, increasing the potential for strategic exploitation of the aquifer. The investigation is largely geochemistry-based, and relies on the ability to acquire samples that can yield meaningful information on the age of waters across the region. The project focuses on three objectives: 1) Age-dating and geochemically characterizing ground waters along a localized North-South transect and defining flowpaths in what is hypothesized to be a dominant recharge area (the Kentucky River valley along the southern border of Jessamine County and the well-constrained fault zones in southern and eastern Jessamine County); 2) Age-dating and geochemically characterizing waters along a North-South transect from eastern Madison County, in the southern Bluegrass Region, to Boone County, in the northern Bluegrass Region, cutting across the central Bluegrass (Clarke, Bourbon, Fayette, Harrison, and Grant Counties) toward a hypothesized discharge zone (the various salt licks that outcrop in the northern Bluegrass Region); and, 3) Defining spatial variations and mixing between freshwater and brines along an East-West transect across the Cincinnati Arch, largely within the inner Bluegrass region.

Methodology

Field Methodology: Existing wells must be prepared for sampling. Pumps and piping systems must be removed from wells where they are not in working condition. Equipment required for this process includes the Kentucky Geological Survey hydraulic pump-hoist truck as well as equipment, purchased during the term of the award, necessary to manipulate well pump and piping systems (pipe clamps and pipe pullers). Once the piping has been removed, each well is video taped using the Kentucky Division of Water's downhole camera. The condition of well walls and the static water level must

be accurately determined before sampling. A deep groundwater pumping system is needed to obtain the most representative water sample possible. This infrastructure does not currently exist in the state of Kentucky, but such a system has been designed in conjunction with Kentucky Irrigation in Lexington, Kentucky.

Analytical Methodology: Bulk geochemical and stable isotopic concentrations will be analyzed in the Environmental Research and Teaching Laboratory (ERTL) at the University of Kentucky. Accelerator mass spectrometry (AMS) analyses of ^{36}Cl will be performed at the Center for Accelerator Mass Spectrometry-Lawrence Livermore National Laboratory (CAMS-LLNL). $^{87}\text{Sr}/^{86}\text{Sr}$ analyses will be performed on a Finnigan MAT-262 thermal ionization mass spectrometer (TIMS) housed at Stanford University. U-series analyses will be performed at the University of Illinois at Chicago (UIC) using a Canberra Alpha Analyst alpha counter (Table 1).

TABLE 1: Proposed analyses, tracer properties, and analysis locations.

Analysis	Tracer Properties	Analysis Location
metals	water chemistry, water-rock interaction, mixing	ERTL, UK
anions	water chemistry, water-rock interaction, mixing	ERTL, UK
dissolved organics	water chemistry, water-rock interaction, mixing	ERTL, UK
D and ^{18}O of water	water origin, mixing	ERTL, UK
^{13}C of dissolved inorganic carbon	water chemistry, water-rock interaction, mixing	ERTL, UK
^{34}S and ^{18}O of dissolved sulfate	redox history, mixing	ERTL, UK
$^{234}\text{U}/^{238}\text{U}$	redox history, water-rock interaction, mixing	UIC
$^{87}\text{Sr}/^{86}\text{Sr}$	water-rock interaction, mixing	Stanford University
^{36}Cl dating	ground water age, mixing	CAMS-LLNL

Bulk geochemical and isotopic modeling of Knox Group waters (speciation, mixing, water-rock interactions) will be accomplished using PHREEQCI, a downloadable freeware program provided and supported by the USGS. Project investigators are familiar with using PHREEQCI to model water evolution and mixing. Associated analytical methods have been developed for the project.

Principal Findings and Significance

- 1) Well Locations: Extensive ground truthing has revealed that only 23 of the 71 recorded Knox wells in the central Kentucky region are viable candidates for this study. Forty-eight wells were eliminated because they no longer exist or they have been plugged. Only 4 of the remaining wells have working pumps. The other 19 wells either lack pumping systems, or the existing pumps no longer function.
- 2) Analytical Infrastructure: Analytical techniques and methodologies have been developed so that sample analysis can proceed. Two trips to the University of Illinois at Chicago have allowed researchers to learn ^{36}Cl dating and U-series analytical techniques. Extraction techniques for obtaining dissolved sulphate samples have been provided by Dr. Barry Maynard at the University of Cincinnati. The equipment for these processes has been assembled and is now housed in Rowe's lab at the University of Kentucky.
- 3) Field Sampling Infrastructure: The ability to obtain representative samples from deep groundwater wells lacking dedicated pumping systems does not currently exist at the University of Kentucky. A mobile pumping system that would allow Knox wells to be appropriately purged and sampled has been designed by the investigators. The system consists of a pump attached to a winch-controlled hosing system that would be permanently installed on a flat bed trailer and towed behind a standard pick-up truck or SUV. Kentucky researchers with potential interest in such a groundwater sampling system are being asked to help support purchase of this system.
- 4) Development of a Local Meteoric Water Line: Rowe has been sampling local meteoric waters which have then been analyzed in ERTL. A permanent meteoric sampling device has been developed and will be installed so that continuous meteoric water samples can be gathered.